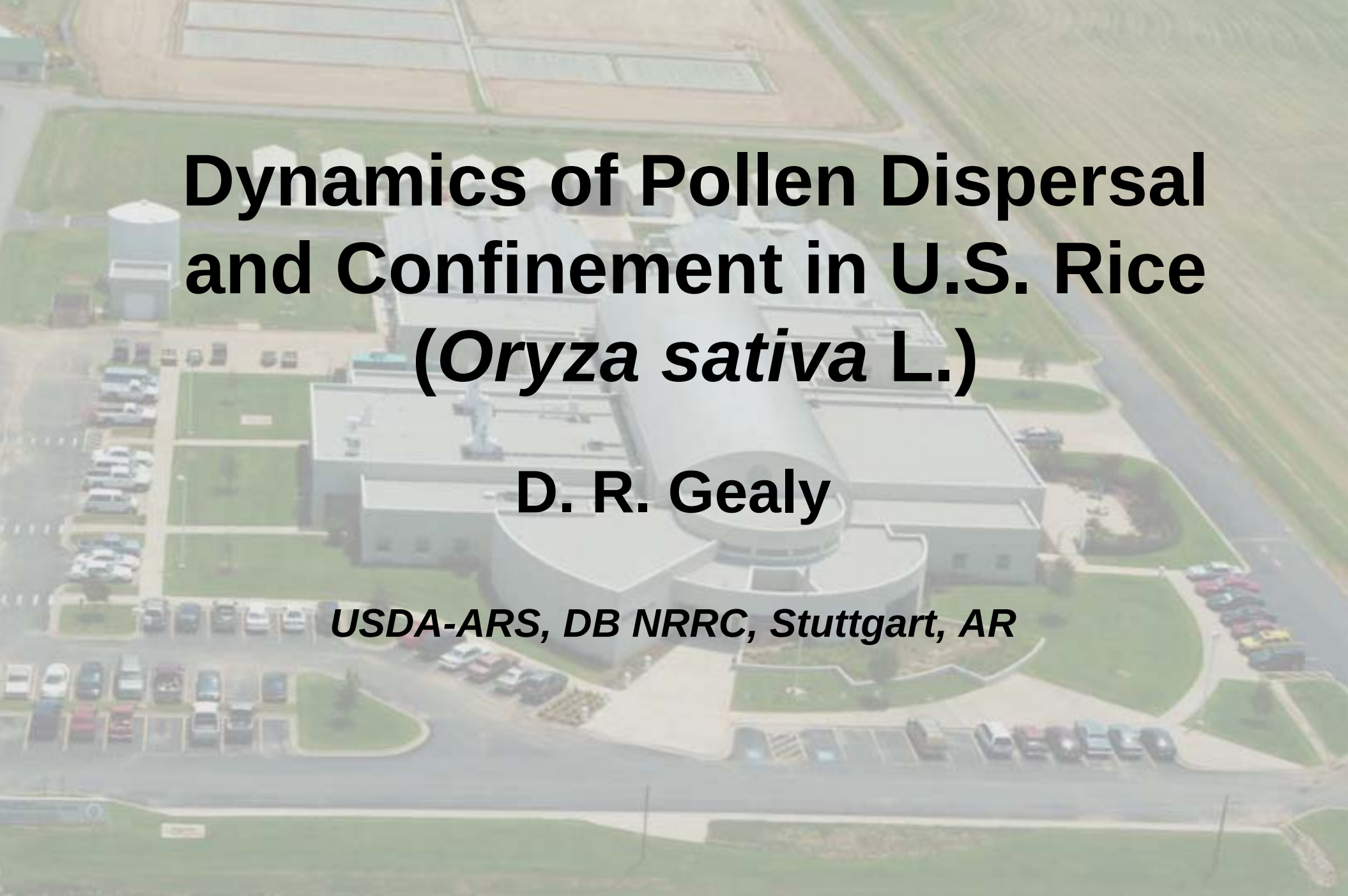


Dynamics of Pollen Dispersal and Confinement in U.S. Rice (*Oryza sativa* L.)

D. R. Gealy

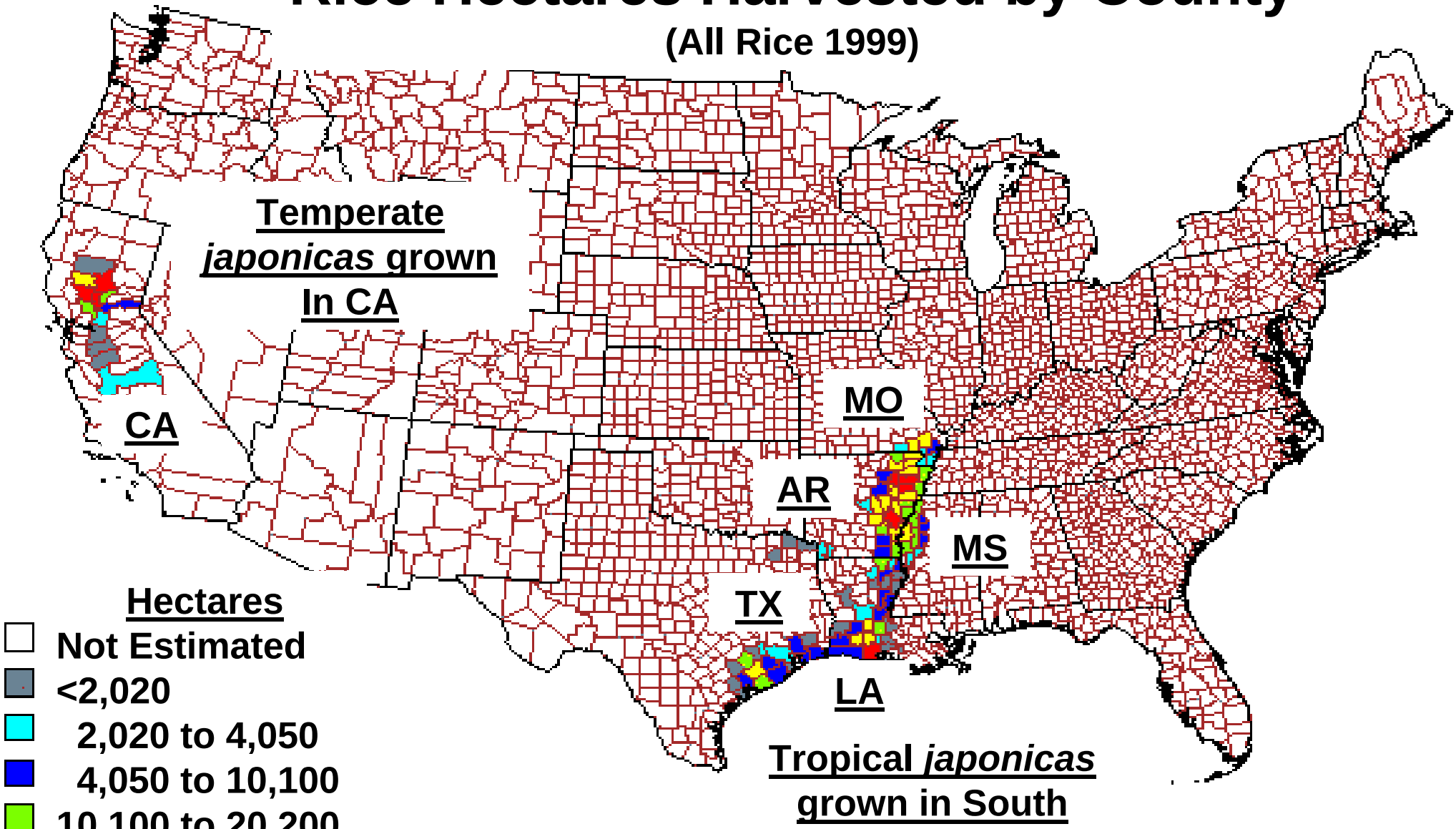
USDA-ARS, DB NRRC, Stuttgart, AR

Objectives

- Rice (*O. sativa*) production & practices
- Weedy red rice (*O. sativa*) and gene flow
- *O. sativa* flowering characteristics
- Outcrossing rates and distances
- Pollen confinement considerations

Rice Hectares Harvested by County

(All Rice 1999)



Recreated from USDA National Agricultural Statistics Service

A look at the past:

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Modern Rice Production

Laser leveling

Land preparation

Drill seeding

Flooding

Rice mill

Maturing grain

Aerial spraying

Combine harvest

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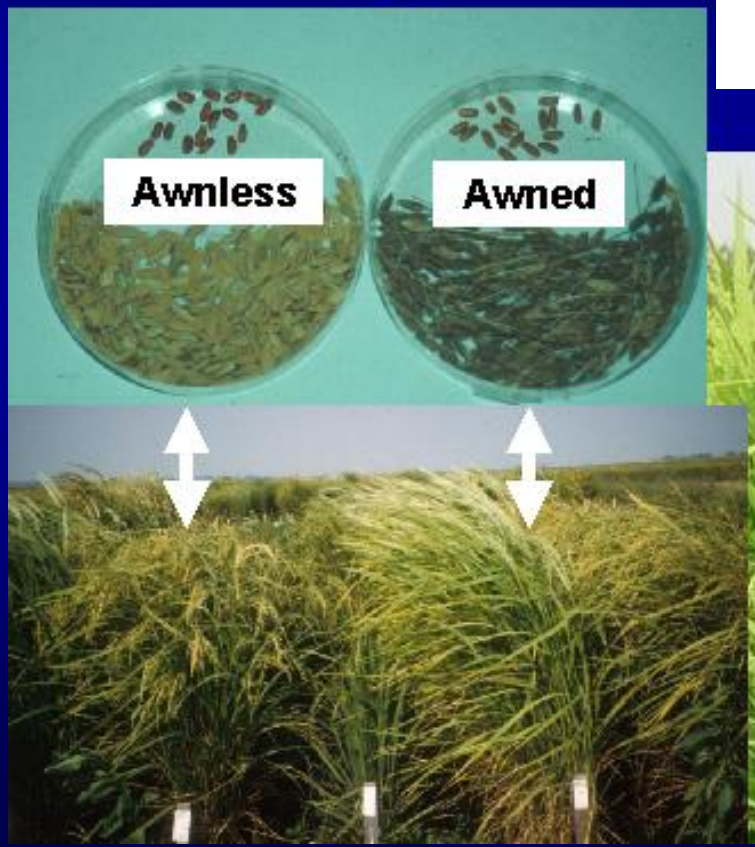
Red Rice is Undesirable Contaminant of White Rice

Commercial rice (long-grain)

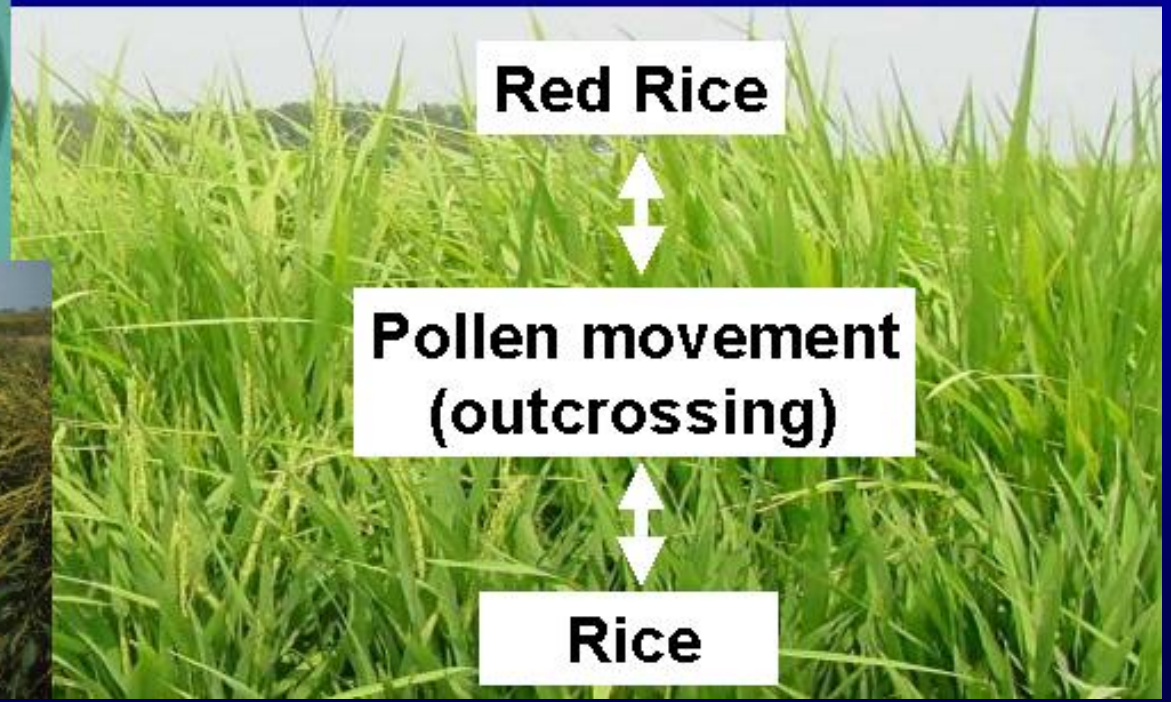
Weedy red rice (medium-grain)

Red rice is a major rice weed and crop mimic in southern U.S.

Red rice types



Outcrossing between red rice and rice occurs in both directions



Herbicide Resistant Rice Systems
(for control of red rice/other weeds)

- **Imidazolinone herbicide (NewPath) used on Clearfield rice or 'IMI rice' (since 2002)**
- **Glufosinate (Liberty) on Liberty Rice (under development)**
- **Glyphosate (Rounup) ??**

(Gealy et al. 2003; Gealy 2004)

Red rice control in IMI rice

(Dillon et al, 1998; Stuttgart, AR)

Untreated

Imazethapyr 0.063 2-3 LF
Imazethapyr 0.063 Prefld

***In 2004 IMI Rice was 15% of all production in South.**
Excellent results, but failures can lead to outcrossing.

Moldenhauer and Gibbons 2003

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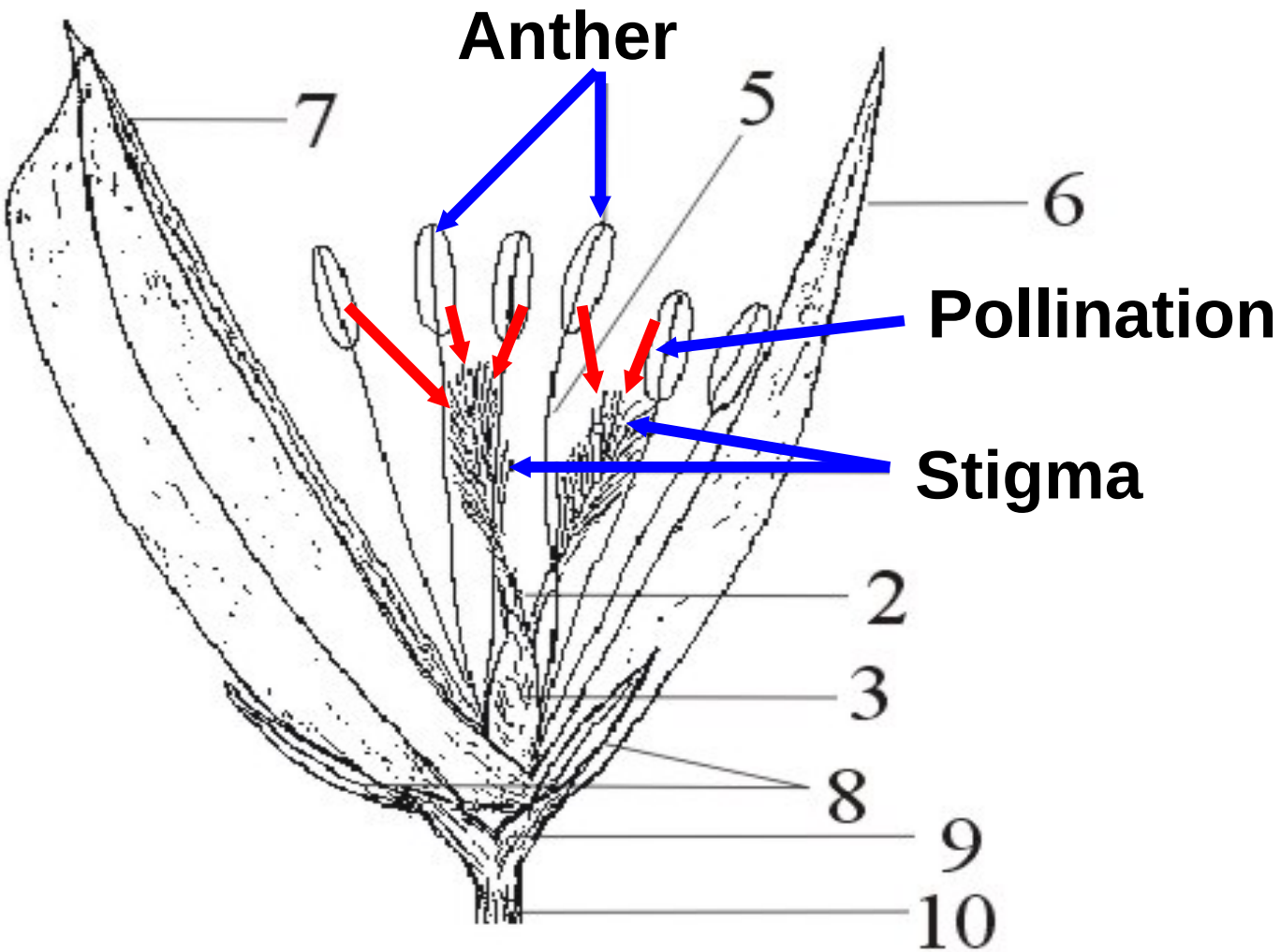
The Rice flower



Pistil
1. stigma
2. style
3. ovary

Stamen
4. anther
5. filament

6. palea
7. lemma
8. sterile lemmas
9. rudimentary glumes
10. pedicel

Outcrossing

Best conditions: bright sun, high RH, warm temp, moving air, (insects?)

Most florets self-fertilize before opening

Released pollen:
-Falls or moves in wind
-Viable 10 min

-Outcrossing mostly < 0.5%
-florets open only 1 hr
-stigma viable several days

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Herb-resistant Red Rice Hybrids (awnless, late maturing)

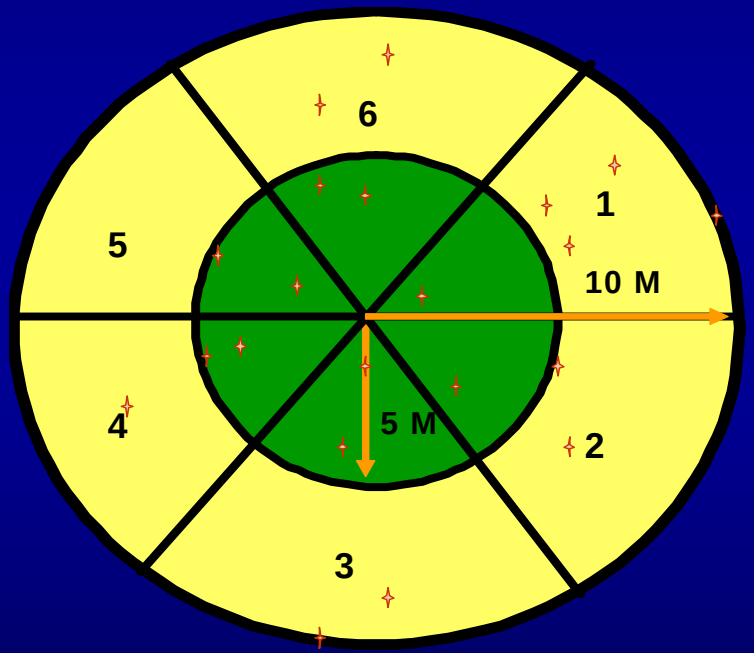
(Burgos et al. 2003)

Red Rice Hybrids (pink awns):

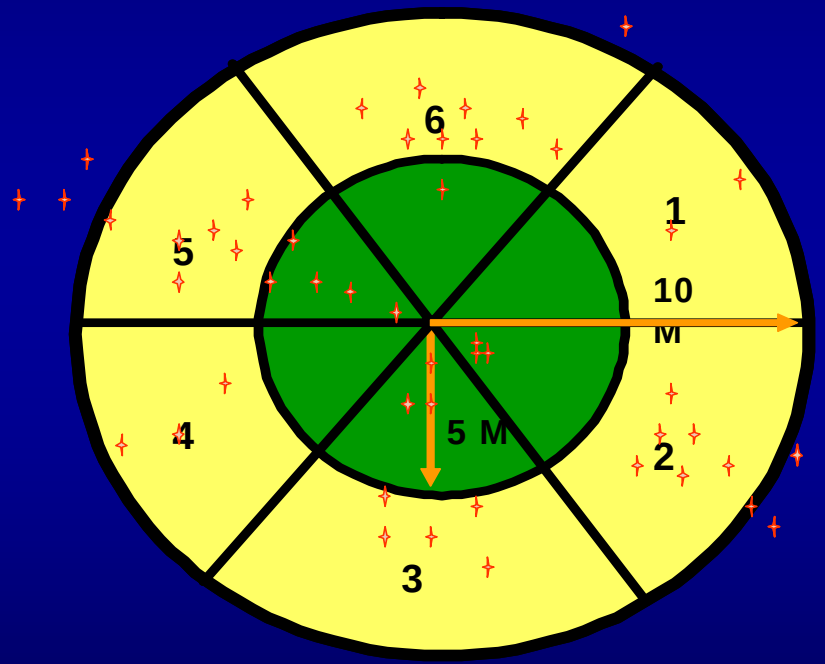
Possible Red Rice Hybrids (awnless, late maturing):

CL161 HR-Rice (center circle) Outcrossing to Red Rice:

April 2003 planting



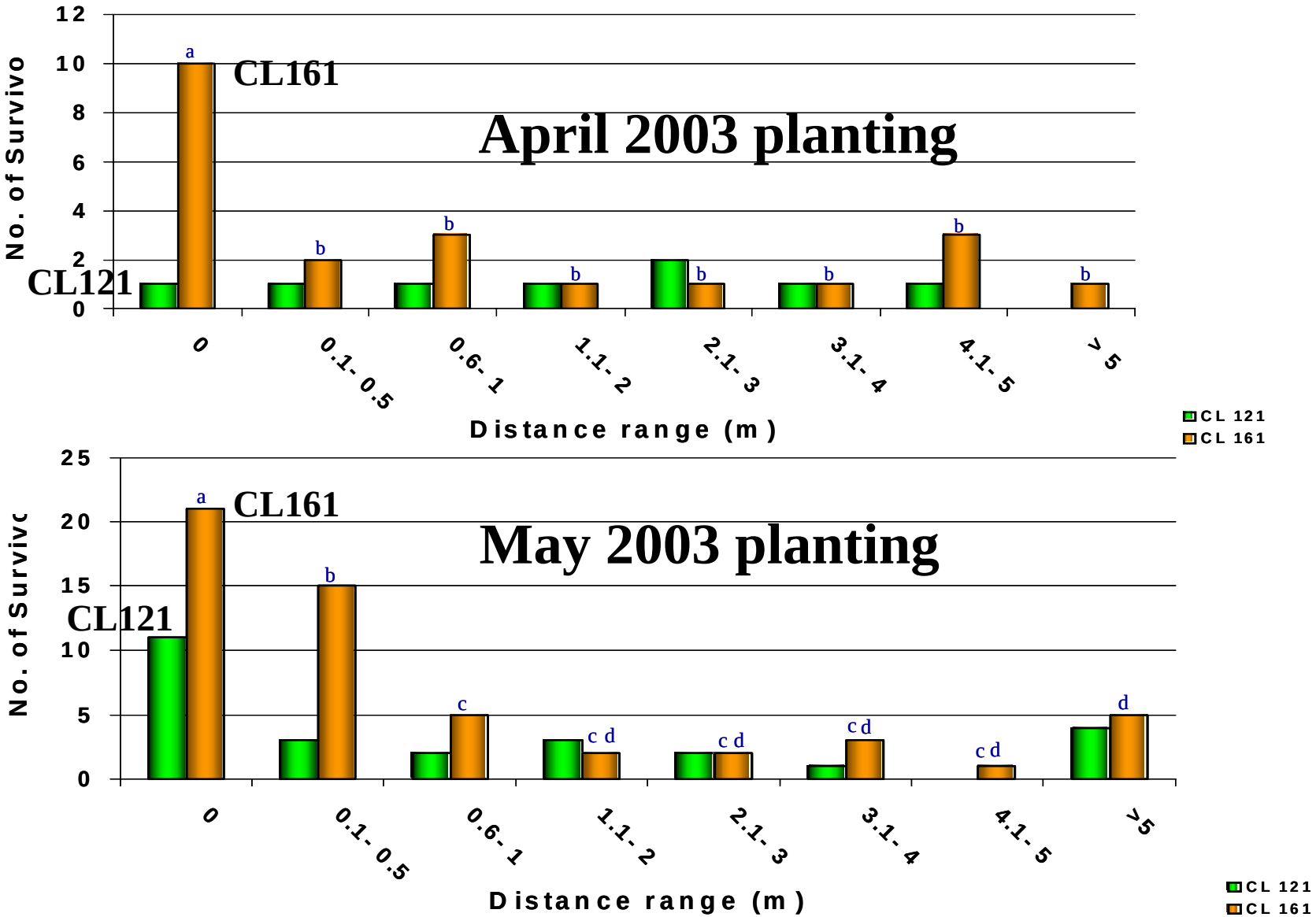
May 2003 planting



Overall averages < 0.01% outcrossing

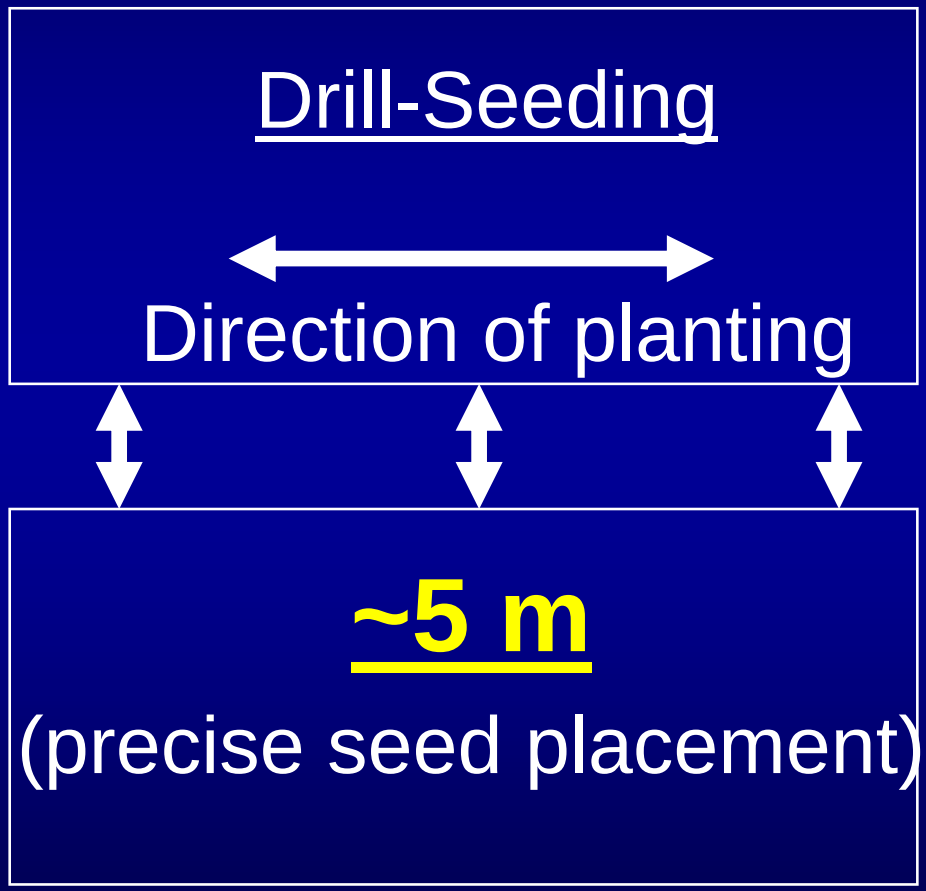
(Shivrain et al. 2004. Note: Data are preliminary. Final results may vary slightly.)

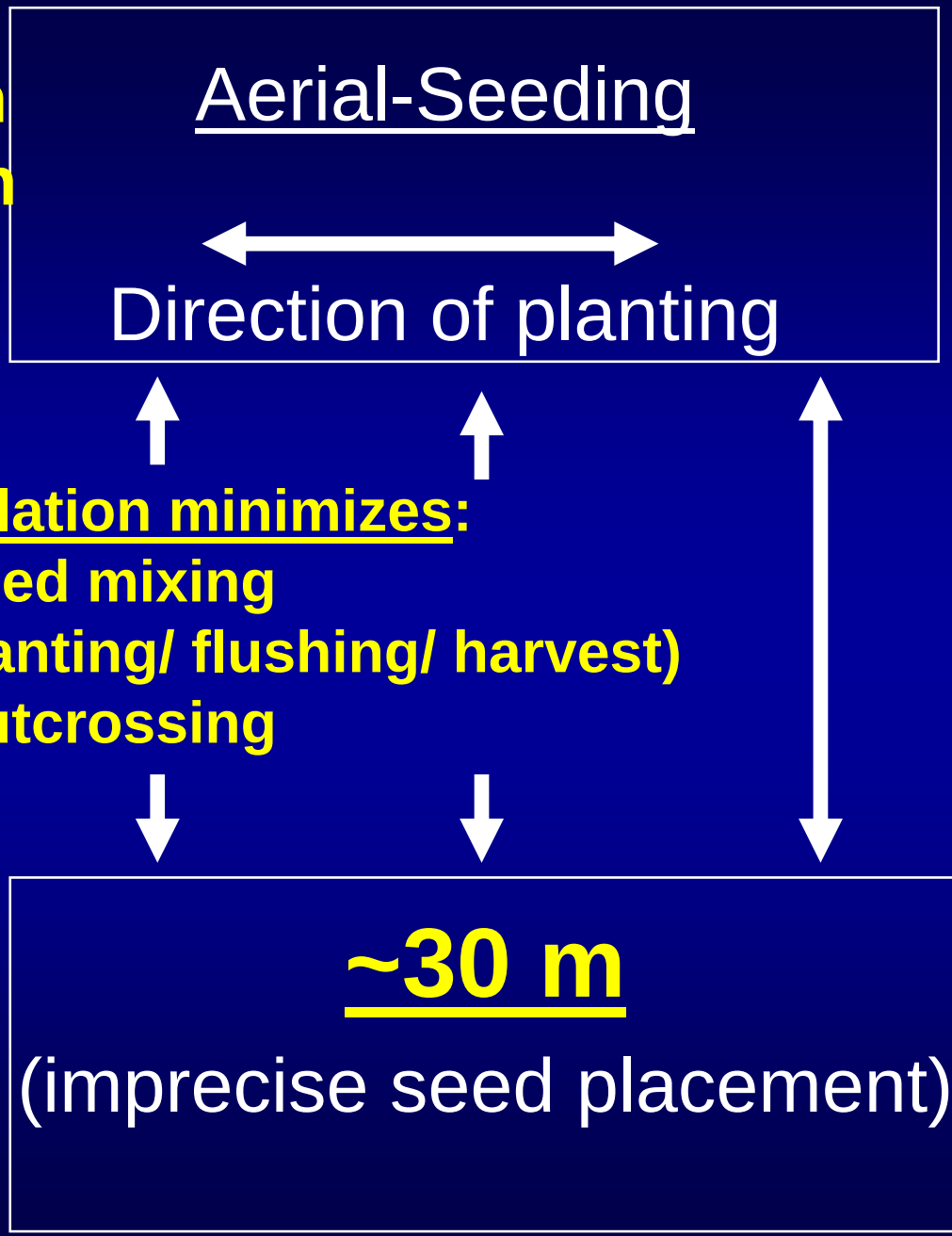
Outcrossing to Red Rice Decreases with Distance



(Shivrain et al. 2004. Note: Data are preliminary. Final results may vary slightly.)

Typical Isolation Distances Between Different Varieties in Certified Rice Seed Production





Gealy et al. 2003

Historic Rice / Rice Outcrossing Study
(adjacent Rows: Beachell et al. 1938)

- 4 cultivar pairs tested in AR, TX, LA, CA
- Avg. ~0.5%; max ~3.5%
- Highly variable: ranged ~28-fold (0.05%-1.4%) over 6 yr for 1 cultivar
- Greater in South (0.52%) than in CA (0.16%): Warmer/ more humid in South, cooler/drier in CA

Average Maximum Outcrossing Rates (adjacent *O. sativa* plants)

- Maximum rates from all rice-rice and rice-red rice studies: avg.=0.17%; range=0-0.7% (Gealy 2004; review).
- Outcrossing to *O. rufipogon* (perennial, wild rice) in Asia >2% (Song et al. 2003; in Asia).
- *indica* (tropical rice) outcrossing usually > *japonica* (temperate rice)

Direction of Pollen Flow With Red Rice (adjacent plants)

- Outcrossing can occur in **both directions**
- Usually greater from red rice (tall) to rice (short). e.g. outcrossing was 0.3% to 0.7% with red rice as pollen donor; undetectable with rice as donor (Zhang et al. 2003)
- Can be nearly equal in both directions (Gealy 2004; review)
- ~95% of hybrid seed formed on **rice** is REMOVED by harvesting equipment while most hybrid seed formed on **red rice** SHATTERS to field (Gealy 2004; review)

Pollen moves in prevailing wind direction

- Outcrossing from HR rice to non-resistant rice was 0.53% 1 m downwind from the pollen source; only 0.015% upwind. Max detection distances ~2.5 to 10m (Messeguer et al. 2001 and 2004, in Europe).
- Outcrossing from HR rice *O. rufipogon* (perennial, wild rice) in Asia detected at 43 m (Song et al. 2003; in Asia).

Outcrossing Summary

- Max for adjacent plants ~ 0.2 - 0.5%
- Max detection distance typically ~2 - 10 m
- Keys: cultivar/ species, flowering synchrony, horizontal & vertical separation, environment, short lived pollen
- Red rice control in HR rice is < 100% (some outcrossing)

Final Thoughts

- Rice pollen confinement decisions require **compromises** between preventing long distance outcrossing and accepting various economic / management limitations.

- Integrating **scientific** and **public policy** inputs is essential.

Special Thanks To:

- Howard Black and Pam Smith for technical assistance
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- University of Arkansas at Fayetteville and University of Arkansas Rice Research and Extension Center at Stuttgart

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